Remarks/Arguments

Prior to this response, claims 1-24 were pending; claims 1-24 were rejected in the above-referenced Office action.

In this response, claims 1-24 are pending.

Indefiniteness rejection of claims 1-24

The Examiner rejected claims 1-24 for indefiniteness based upon use of the term "progressively" in claims 1, 10, 13 and 22 (in lieu of 20 in the Office action, which appears to be a typographical error).

Paragraph 0015 of the pending specification (page 2-3) reads as follows:

> "**FIG. 3(a)** through **FIG. 3(f)** illustrate one non-limiting example of a time-power management scheme executed by control system **28** to achieve directional solidification. In all of these figures, the x-axis represents time, and the y-axis represents normalized output power of power supply **24**. Power control may be accomplished by changing the supply's output voltage magnitude; output current magnitude; or a combination of output voltage and current magnitudes. One or more of the six induction coils receives output power from supply **24** for a time period within a power supply cycle period, which is identified as $\mathbf{T_{CYCLE}}$ in the figures. In the first series of power supply cycle periods shown in **FIG. 3(a)** all six coils receive power in each cycle period for time period $\mathbf{T_{CP1}}$. While $\mathbf{T_{CP1}}$ is equal for all coils, in other examples of the invention, coil power periods may vary. The coil power switching scheme in **FIG. 3(a)** cyclically repeats as shown for $\mathbf{T_{CYCLE}}$ until time $\mathbf{T_1}$. At this time, the power switching scheme continues in **FIG. 3(b)** wherein induction coil **1** receives no power in a power supply cycle period. In this second series of power supply periods, coils **2** through **6** receive power in each cycle period for time period $\mathbf{T_{CP2}}$. Since $\mathbf{T_{CP2}}$ is greater than $\mathbf{T_{CP1}}$, output power is proportionately reduced (normalized 0.833 output power since time period $\mathbf{T_{CP2}}$ is 1.2 times longer than $\mathbf{T_{CP1}}$) to maintain the same amount of electrical energy to each induction coil. The coil power switching scheme in **FIG. 3(b)** cyclically repeats as shown for $\mathbf{T_{CYCLE}}$ until time $\mathbf{T_2}$. Similarly progressive power switching schemes are sequentially executed as illustrated in **FIG. 3(c)** through **FIG. 3(f)** wherein one additional coil receives no power in each progressive power supply cycle shown in each figure. <u>In this fashion inductive heating of the molten metal in the vessel progressively decreases from the bottom to the top of the molten mass.</u>" (underline added)

In paragraph 0018 of the present specification (page 5, lines 6-9), it is stated that "[a]fter the required induction heating of the molten mass with all coils being powered as shown in **FIG. 3(a)**, the time period for each coil power switching

scheme illustrated in **FIG. 3(b)** through **FIG. 3(e)** may be as long as one or more days."

Applicants submit that the filed specification and drawings sufficiently describe the term "progressively" and that the skilled artisan would be reasonably apprised of the scope of the invention therefrom.

Rejection of claims 1-3, 5, 6, 10, 11, 13-15, 17, 18, 22 and 23 as being anticipated by Schluckebier et al (US 5,135,781)

Prior to discussion of the cited references, Applicants point out that the present invention includes directional solidification of a molten metal in a vessel by decreasing the amount of heat applied to the molten metal by electric induction from the bottom to the top of the vessel.

Referring to the Examiner's discussion of Schluckebier et al on Page 2 (first full paragraph from the bottom of the page) of the Office action, Applicants point out that the Schluckebier et al apparatus is used for coating a metal strip (6) that is dipped into a molten metal (smelt 8). See col. 2, lines 23-28. Top induction coils 3 and 4 are selectively powered from a single phase ac source (13) (col. 2, lines 32-38) when heating the smelt or, alternatively, powered together with remaining coil 5 from a three phase source (15) (col. 2, lines 45-57) to agitate deposits (10) that collect at the bottom of the crucible as a result of the coating process. The agitation suspends the particles in the melt for collection by a colleting vessel immersed into the melt (col. 2, line 65 through col. 3, line 5). Therefore Schluckebier et al does not teach a means for selectively applying ac current to each of a plurality of induction coils to inductively heat the molten mass of the metal in the vessel with applied heat progressively decreasing from the bottom to the top of the molten mass of the metal in the vessel, whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel, as recited in pending claim 1. In Schluckebier et al, either both or one of the two top coils have ac current applied to them to heat the melt for the coating process, or all three coils have ac current applied to them to cause electromagnetic stirring of the melt to agitate deposits at the bottom of the melt. Anticipation requires, in part, that Schluckebier et al teaches each of the claimed elements. For the above reasons, Applicants submit that pending claim 1 is

not anticipated by Schluckebier et al. For the same reasons, Applicants submit that claims 2, 3, 5 and 6, which are directly or indirectly dependent upon claim 1, are not anticipated by Schluckebier et al.

Pending independent claim 10 includes the steps of selectively supplying an ac current to each of a plurality of induction coils to heat the molten mass of the metal in the vessel, and progressively decreasing the applied heat by induction from the bottom to the top of the molten mass of the metal in the vessel to solidify the molten mass in the vessel from the bottom to the top of the vessel. For the above reasons, Applicants submit that claim 10 is not anticipated by Schluckebier et al. For the same reasons, Applicants submit that claims 11, which is directly dependent upon claim 10, is not anticipated by Schluckebier et al.

Pending claim 13 includes a means for selectively applying ac current to each of a plurality of induction coils to inductively heat a susceptor vessel with applied heat progressively decreasing from the bottom to the top of the susceptor vessel whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel by heat transfer from the susceptor vessel to the molten metal mass of the metal in the vessel. For the above reasons, Applicants submit that claim 13 is not anticipated by Schluckebier et al. For the same reasons, Applicants submit that claims 14, 15, 17 and 18, which are directly or indirectly dependent upon claim 13, are not anticipated by Schluckebier et al.

Pending claim 22 includes the steps of selectively applying an ac current to each of a plurality of induction coils to heat a susceptor vessel to heat by conduction and radiation a molten mass of the metal in the susceptor vessel, and progressively decreasing the applied heat by induction from the bottom to the top of the susceptor vessel to solidify the molten mass in the susceptor vessel from the bottom to the top of the vessel. For the above reasons, Applicants submit that claim 22 is not anticipated by Schluckebier et al. For the same reasons, Applicants submit that claim 23, which is directly dependent upon claim 22, is not anticipated by Schuluckbier et al.

<u>Rejection of claims 1, 3-7, 9-13, 15-19 and 21-24 as being anticipated by Tsuda et al (US 6,307,875)</u>

Referring to the Examiner's discussion of Tsuda et al (paragraph beginning at bottom

of Page 2 and ending at top of Page 3 of the referenced Office action), Applicants point out that the Tsuda et al apparatus is a generally funneled-shaped cold induction crucible used to melt (not solidify) a metal (col. 6, lines 5-14). Two induction coils are used. The first coil (5) is used exclusively to melt the metal placed in the cold crucible. The second coil (6) is used exclusively to melt the solid layer of skull (14) around the bottom tapping portion (2) of the cold crucible when the molten metal in the crucible is ready to be tapped from the bottom of the cold crucible (col. 7, lines 62-64), and to control the flow rate of the molten metal through the tap by adjusting the frequency of the current supply to coil (6), which controls the amount of skull in the tap used to restrict flow through the tap. As described in Tsuda et al, a cold crucible process includes formation of a solid layer of skull (14) between the crucible wall (but not a solid metal mass in the crucible) and the molten metal in the crucible to prevent reaction of the molten metal with the material of the crucible wall. In the cold crucible induction process, the crucible wall (4) has interior cooling channels (4a) to form the layer of skull by freezing metal in contact with the wall. Coil (5) is powered exclusively from melt-use power source (7) and coil (6) is powered exclusively from tapping-use power source (8). Control means (12) controls the melting in the crucible and pouring from the crucible. The Examiner refers to Figure 8 of Tsuda et al. In this figure, a starting block (19) is inserted into the tapping portion (2) of the crucible to pull the solidified skull (14) in the tap out by force applied by drawing device (20) when molten metal is to be tapped from the crucible. In the present invention, the entire solidified metal mass can be pushed out of the vessel (paragraph 0018 of the filed specification). In FIG. 12(A)-12(C) Tsuda et al also discloses a third embodiment (col. 12, line 43 through col. 14, line 35) of a furnace that includes a cylindrical wall (33) chamber. However that chamber is combined with a funnel-shaped tapping portion (21) in the bottom wall (34) of the chamber that functions similarly to the Tsuda et al funnel-shaped furnaces. Therefore Tsuda et al does not teach a means for selectively applying ac current to each of a plurality of induction coils to inductively heat the molten mass of the metal in a vessel with applied heat progressively decreasing from the bottom to the top of the molten mass of the metal in the vessel, whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel,

as recited in present application claim 1. Anticipation requires, in part, that Tsuda et al teaches each of the claimed elements. Regarding pending claim 1, Tsuda et al does not teach a means for selectively applying ac current to each of the plurality of induction coils to inductively heat the molten mass of the metal in the vessel with applied heat progressively decreasing from the bottom to the top of the molten mass of the metal in the vessel, whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel. Tsuda et al teaches using a plurality of induction coils wherein <u>some</u> of the induction coils are <u>dedicated</u> to melting a metal in a cold crucible and the <u>remaining</u> induction coils are dedicated to controlling the melting of the skull formed in a bottom tap of the crucible to control the flow rate of molten metal from the crucible. For the above reasons, Applicants submit that pending claim 1 is not anticipated by Tsuda et al. For the same reasons, Applicants submit that claims 3-7, and 9, which are directly or indirectly dependent upon claim 1, are not anticipated by Tsuda et al.

Pending independent claim 10 includes the steps of selectively supplying an ac current to each of a plurality of induction coils to heat the molten mass of the metal in the vessel, and progressively decreasing the applied heat by induction from the bottom to the top of the molten mass of the metal in the vessel to solidify the molten mass in the vessel from the bottom to the top of the vessel. For the above reasons, Applicants submit that claim 10 is not anticipated by Tsuda et al. For the same reasons, Applicants submit that claims 11 and 12, which are directly dependent upon claim 10, are not anticipated by Tsuda et al.

Pending claim 13 includes a means for selectively applying ac current to each of a plurality of induction coils to inductively heat a susceptor vessel with applied heat progressively decreasing from the bottom to the top of the susceptor vessel whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel by heat transfer from the susceptor vessel to the molten metal mass of the metal in the vessel. For the above reasons, Applicants submit that claim 13 is not anticipated by Tsuda et al. For the same reasons, Applicants submit that claims 15-19, and 21, which are directly or indirectly dependent upon claim 13, are not anticipated by Tsuda et al.

Pending claim 22 includes the steps of selectively applying an ac current to each of a

plurality of induction coils to heat a susceptor vessel to heat by conduction and radiation a molten mass of the metal in the susceptor vessel, and progressively decreasing the applied heat by induction from the bottom to the top of the susceptor vessel to solidify the molten mass in the susceptor vessel from the bottom to the top of the vessel. For the above reasons, Applicants submit that claim 22 is not anticipated by Tsuda et al. For the same reasons, Applicants submit that claims 23 and 24, which are directly dependent upon claim 22, are not anticipated by Tsuda et al.

<u>Rejection of claims 8 and 20 as being obvious over Tsuda et al in view of Fukuzawa et al (US 5,416,796)</u>

Pending claim 8 is dependent upon claim 1; claim 20 is dependent upon claim 13.

Tsuda et al was previously discussed above. Fukuzawa et al discloses an induction cold crucible that has a stationary upper part (11) and a lower closed-bottom part (12) that can be lowered away from the upper part as a columnar metal (19) is formed within the crucible. Solid cold metal (20) is added to molten metal in the crucible as the bottom part of the crucible is lowered. Molten metal surface thermometer (23) senses the temperature of molten metal in the crucible, and when the sensed temperature exceeds a desired range, additional cold material is added to the melt (col. 3, lines 55-61). Molten metal surface level gauge (24) measures the level of molten metal in the crucible, and when the sensed level exceeds a desired range, lowering of the bottom part of the crucible is stopped (col. 3, lines 62-68).

Pending independent claim 1, recites in part, a means for selectively applying ac current to each of the plurality of induction coils (surrounding a vessel) to inductively heat the molten mass of the metal in the vessel with applied heat progressively decreasing from the bottom to the top of the molten mass of the metal in the vessel whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel. Claim 8, which is dependent upon claim 1, recites a sensor means to sense the progress of solidification of the mass of molten metal from the bottom to the top of the vessel. Applicants submit that Tsuda et al in combination with Fukuzawa et al does not make obvious use of a sensor, as recited in claim 8, to sense the progress of solidification of a molten mass in a vessel as inductively heated in claim 1.

Pending independent claim 13, recites in part, a means for selectively applying ac current to each of the plurality of induction coils (surrounding a susceptor vessel) to inductively heat the susceptor vessel with applied heat progressively decreasing from the bottom to the top of the susceptor vessel whereby the molten mass solidifies in the vessel from the bottom to the top of the vessel by heat transfer from the susceptor vessel to the molten mass of the metal in the vessel. Claim 20, which is dependent upon claim 13, recites a sensor means to sense the progress of solidification of the mass of molten metal from the bottom to the top of the vessel. Applicants submit that Tsuda et al in combination with Fukuzawa et al do not make obvious use of a sensor, as recited in claim 20, to sense the progress of solidification of a molten mass in a susceptor vessel as inductively heated in claim 13.

Applicant respectfully requests allowance of all pending claims.

Respectfully submitted,

By: Philip O. Post 18 January 2006

PHILIP O. POST, Esq.
USPTO Reg. No. 28,456
Indel, Inc.
Post Office Box 157
Rancocas, New Jersey 08073

Telephone: (609) 267-9000, ext. 254
Facsimile: (609) 267-5705

CUSTOMER NO. 31855